Canonical Babbling: A precursor to speech for young Cochlear Implant Recipients

P. Binos

Binos Paraskevas[1], Okalidou Areti[1]
1. Department of Educational and Social Policy, University of Macedonia, Egnatias 156, 54006, Thessaloniki, Greece

Corresponding Author:
Paraskevas Binos, Department of Educational and Social Policy, University of Macedonia, Egnatias 156, 54006, Thessaloniki, Greece,
Phone: +306934223402,
email: pariss61@hotmail.com

Abstract

Background: Human speech is structured by the constraints of physiological mechanisms whose first use is nonlinguistic. Canonical Babbling (hereafter, CB), the result of multiple articulatory movements in one breath, represents a developmental milestone in linguistic development. Infants and toddlers produce it despite their socioeconomical status or their different language backgrounds including multilingual ones. **Clinical Presentation:** CB is fundamental for the transition from premature to mature-adult language patterns. Canonical pre-linguistic vocalizations include the well-formed syllables which are necessary for meaningful adult speech. There are numerous studies stressing out that the similarities of Canonical Babbling with early speech leave no doubt that these vocalizations of typically developing children (TD) are indeed precursors to speech1. Moreover, late onset of CB is related with deafness2,3. **Implications:** Clinical implications concerning very young cochlear implant recipients conclude that the sooner the implantation the better the possibilities for the recipients to "catch up" to the typically developing infants4. The need for valid diagnostic tests to assess the pre-linguistic speech of young hearing impairment based on the onset of CB is now stronger. **Future Prospects:** As Ertmer and Inniger5mention, extra care should be given for valid evaluation of post-implantation spoken word development.

Keywords: canonical babbling, cochlear implantation, deaf, speech production

Introduction

Today, there are more than 30 years since Stark6 and Oller[7] related the prelinguistic vocal development, hereafter called "vocal development"[8], with a regular transition to adult-mature language. This approach developed in contrast with other researchers[9,10] who argued against the role of early vocalizations (protophones) as precursors to speech through the "discontinuity theory". Today, the research of these volitional sounds is extended not only to typical populations but to deaf and hard-of-hearing children as well[11,12].

Oller13 tried to describe his infraphonological theory more as a model which sets some rules that infant's speech can abide. Hence, he did not develop a classification model per se that predetermines where each type of vocalization belongs. This is the reason, along with the implementation of different methodologies, why there are today so many differences among theories presenting different developmental stages of babbling. Researchers set different, age limitations between the Protophone Stages, and propose different taxonomies of vocal types [6,8,13-21]. Thus, each theory contains some underlying assumptions that permit different approaches. For example, Oller[7] stated five developmental stages the Phonation, Cooing, Expansion, Canonical and Variegated. On the other hand, recent research, guided by the everyday clinical need for simple and functional diagnostic tools, has merged these stages into three basic categories, creating reliable and valid tools[8,16].

Onset of Canonical Babbling as predictor of Hearing and Other Disorders

As Harold and Barlow[22] state, the importance of Canonical Babbling is theoretically documented now[1,13,23,24]. Therefore, there is a growing need for valid diagnostic tools that won't be time consuming and at the same time will focus on the onset of Canonical Babbling (CB) Stage as a language-driven developmental stage of early premature infant vocalizations[17,25]. Despite the first observations that located it at 10 months of age, there are findings which specify its onset at 5 months of age for TD children[26]. Also, as Oller et al1 mention, late start of CB possibly connected with the diagnosis of other language disorders like apraxia, dysarthria, specific phonological disorders, and general language disorders or even with the emergence of hearing disorders and autism.

Based on the above, the emergence of CB as a diagnostic developmental factor has many clinical implications for ENT patients like the young cochlear implant recipients. Thus, the onset of CB is often examined as a function of variables such as age of implantation and post-implant age. Through the study of CB it may also become possible to predict the speech developmental stages of CI recipients that emerge later on and understand how their auditory input, provided by their implants, affects the early progression towards these language developmental stages. This is the reason that today's research in the speech features of CIs is focused on Canonical and Post-Canonical vocal types. According to research[27,28] the prelinguistic vocalizations that are classified as Pre-Canonical (PL) are relatively immature patterns, observed both in typically developing children (TD) and children with hearing loss who wear hearing aids. In addition, it has been noted that the initial vocal types across TD children and children with cochlear implants (CI) are similar, thus, they are able to provide limited information about the CI effect[29]. Also, as Schauwers et al[30] state the PL vocalizations are physiologically driven and may not require the auditory input in order to be produced. Reflexive, vegetative sounds as well as isolated vowels are some of the components of this developmental stage of PL and do not abide in the basic principle of infraphonology, that is the rapid formation of supraglottal articulation of CV type that sets up the CB stage[13]. The opposite stands for the "rhythmic" vocalizations in CB which are gradually based on auditory input, as is mentioned below.

CB and CIs

Warner-Czyz et al[31] mention the existence of CB across diverse languages. This is because according to studies of early speech acquisition, the most basic component of CB, the CV pattern is the result of a rhythmic mandibular movement, a common characteristic across languages. For example, a period between 6-7 months of age

for the onset of CB in TD children is found by Kishon-Rabin et al[32] in Hebrew while implantation seemed beneficial for vocal development of CIs (implanted between 11-29 months of age). Delays in the onset of CB for hearing disordered children are extensively documented but the same does not stand for CI recipients.

In the Warner-Czyz et al[31] study, CI recipients (implanted < 2 years old) showed the same level of Consonant-Vowel syllabic accuracy with their TD peers who had the same vocal developmental level. Moore and Bass-Ringdahl[33] mention the onset of CB at 6.5 months after activation of the implant (CIs implanted between 18-20 months of age) while "Hannah", a child from Ertmer and Mellon[29], needed only 5 months after activation (implanted at 19 months of age). Schramm et al[34] note the onset of CB for German-speaking children between 0-4 months after the first fitting, if the children receive it by16 months. At the same time the onset of CB for TD children was between 4-9 months. In this study, the onset of CB occurred between 13-16 months of age for young CI recipients who were implanted by the age of 16 months. In agreement with Schramm et al 34 Schauwers et al[11] found the onset of CB in10 German-speaking children with CI who received their implant during the second half of their first year was (implanted between 5-20 months of age) was 1-4 months. The age of implantation was also related with the babbling level in Schauwers et al[35], since all CI recipients started babbling 1 to 4 months after activation and the youngest CI participants had comparable onset of CB to that of TD peers. Schramm et al[34] emphasized also the need for valid early diagnostic tools for the assessment of prelingual speech of infants with hearing impairments.

Except the previously described differences for the onset of CB in CIs versus TD children, some studies have conducted more qualitative analyses of CB. Thus, Schauwers et al[11] conducted a three level analysis of prelexical babbling for 10 CIs (implanted between 1-2 years old) and 10 TD children, trying to find some inner differences in this stage between the two groups. The research was conducted in segmental, intrasyllabic and intersyllabic level. Young CIs had less vocalizations of variegated babbling (CVCV) and CV combinations were produced earlier for TD than CIs. Finally, it was concluded that CIs preferred simplicity to complexity as far as variegated syllables are concerned and late-fitted recipients were able to produce CV vocalizations in earlier stages of the babbling period. The rapid progress in vocal development of CIs is also mentioned by Ertmer and Young[17]. It is worth mentioning that Ertmer et al36 revealed that young CIs need more time to build a robust vocal profile in contrast with CIs implanted at older ages. But, as Ertmer and Inniger[5] mentioned, more research is needed to be done on the pre-implant advancements of physical, cognitive and social factors in order to unravel the maturational parameters that interact with the auditory experience of young CI recipients.

Challenge approaches and future perspectives

The study of early vocalization patterns in TD infants and children with hearing loss can increase our understanding for the relation between perception and production in vocal development and enrich the knowledge of prelinguistic vocalization rules that govern the early stages of the language-acquisition process[37]. Classification models of vocal development are important, providing not just some chronological stages, as previously found for TDs and CIs, but detailed descriptions of protophone classifications which surpass the taxonomy problems brought by the auditory transcription of babbling patterns. This can be achieved by taking into account acoustical, spectral and suprasegmental evidence that underlies the production of protophones.

The further study of protophones might resolve controversies regarding their developmental classification. For example, Oller's theory classifies VC vocalization as a type of Canonical Babbling even though Ertmer and Joung8 categorized VC pattern as post-canonical vocalization, implying great maturity for this closed-type of vocalization. So, despite Oller's opinion that approaches dealing with issues like that mentioned above fail to "see the forest for the trees"[38] (p.112) these perspectives are necessary for every day clinical practice. For example, speech sampling is one tra-

ditional way of assessing vocal development and the most "naturalistic method" for depicting developmental changes of phonetic repertoire after implantation[17].

So, it is necessary for experts to be equipped with a detailed and complete protophone classification model that is particular to one's language without disagreements about the classification of each vocal type.

Conclusion

In the majority of the studies, the onset of canonical babbling is a developmental marker that can be a useful tool for ENT practitioners for mapping the developmental progress of speech of young CI recipients. Thus, the implant's effect can be measured and classified into the developmental stages of protophone classification models suggested so far. Moreover, future studies should examine the transition from protophone production to lexical acquisition for children with CI and develop valid measurements for their CV accuracy in comparison with their TD peers[32].

As Fitzpatrick et al[39] mention more research is required for the long-term effects of CI for recipients implanted between 2 and 5 years. The role of the family is crucial since they can provide detailed information about the onset of CB[40].

Conflict of Interest

The authors have no competing interests to declare.

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